

NOTES AND CORRESPONDENCE

On Weather Analysis and Forecasting over the Indo-Tibetan Region

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The Tibetan plateau is perhaps the largest mountain region in the world with an expanse of nearly 2×10^6 km². As is usually the case in mountain regions, the Tibetan plateau has very poor network of upper air observatories. Moreover, the only two such observatories of the region (Bamtso, 32°00'N 92°07'E, and Lhasa, 29°43'N 91°02'E) are situated in its southeastern, rather than its central part. Consequently, routine synoptic upper air analysis over the region involves large linear interpolations from the data of adjoining regions. Such interpolations imply that the vast Tibetan Plateau is climatically homogeneous and its weather and circulation can be represented by observations from adjoining regions. This is highly questionable since mountain systems are known to generate their own circulation and weather. Apart from this, linear interpolation at a certain altitude becomes unrealistic if we ignore the presence of mountain barriers extending above that altitude because they permit no direct exchange of air mass horizontally through them and thus act as a climatic divide. At what altitudes over the Tibetan Plateau and on what occasions the linear interpolations are rendered unrealistic has not been considered seriously so far. This is an important prob-

lem not only for weather analysis and forecasting over Tibet and its adjoining countries but also for understanding the interaction between the tropics and extratropics over Asia.

From the published literature it can be seen that upper air analyses for the Tibetan Plateau are not generally made for isobaric levels below 500 mb. Considering the average elevation of the Tibetan Plateau (4.5 km), upper air analyses over Tibet for levels < 500 mb are quite unrealistic. Although all of the other standard isobaric levels are included in the analyses, the 500-mb level poses certain problems.

Over the Tibetan Plateau and its neighboring regions, the height of the 500-mb pressure surface is invariably < 6000 m. During different seasons it generally varies between 5400 and 5700 m, the average being about 5500 m. It may be pointed out that for reporting winds at 500 mb by pilot balloon stations, the standard geometric height is 5.4 km MSL.

From an examination of the topographic map of the region (Fig. 1), prepared on the basis of the topographic data compiled by Berkofsky and Bertoni (1960), it is seen that the Kunlun and the Everest ranges exceed the average height of the 500-mb pressure surface by

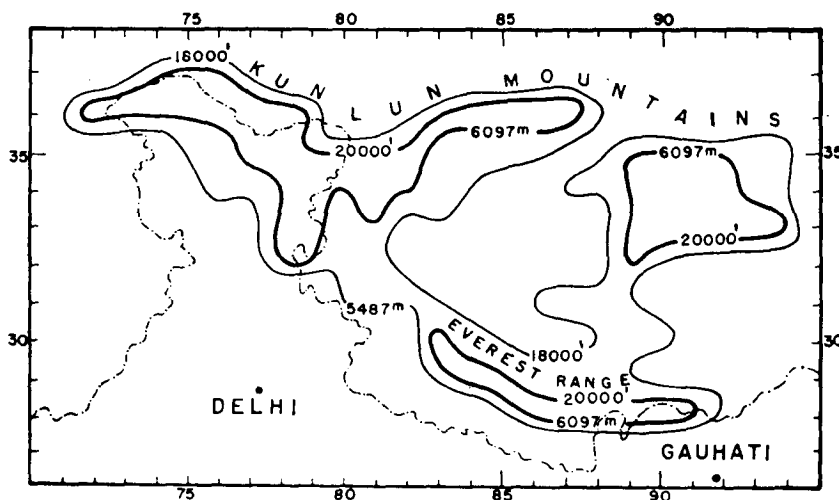


FIG. 1. Height countours at 18,000 and 20,000 ft of the Indo-Tibetan region.

about 600 m. The latitudinal extent of these ranges is not generally more than 1° and they are oriented mainly west-east. Therefore, for the normal planetary westerly winds of the region, these ranges, in general, may not be a serious obstruction at 500 mb. But when there is a wave perturbation, usually indicating a low-index situation, and the airstreams are directed so as to intersect these barriers, some modifications are bound to occur to the stream flow.

Normally under low index situations, the waves at 500 mb in the middle latitudes of the Asiatic region

have a wavelength of $\sim 40^\circ$ of longitude (~ 4000 km). Since the length of the Kunlun range is ~ 2200 km ($72\text{--}94^\circ\text{E}$), the meridional flow of nearly half the wave can be obstructed by this barrier. Similarly, the Everest range, with a length of about 800 km ($83\text{--}91^\circ\text{E}$) may also influence the waves. Of the two barriers, the Kunlun appears to be more important because it occupies practically the entire northern boundary of the Tibetan Plateau which, in turn, is the border of India.

To examine these aspects, Figs. 2–6 show typical

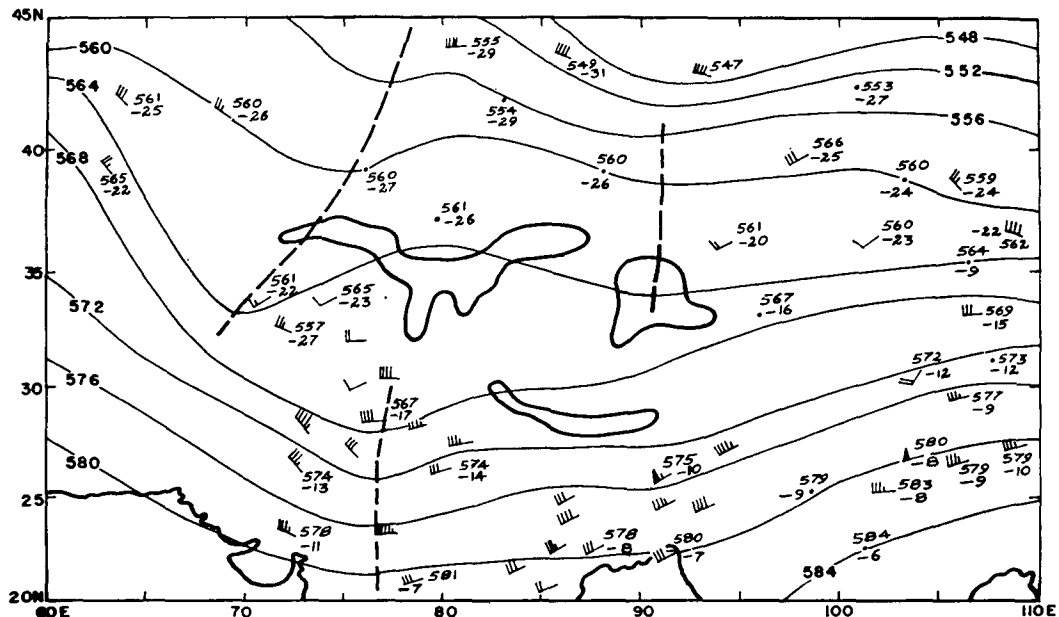


FIG. 2. 500-mb chart of 23 November 1970 at 0000 GMT. Pressure contours are given in geopotential decameters and temperature in degrees Celsius. Dashed lines indicate the trough axes. The 20,000 ft height contours have been reproduced from Fig. 1.

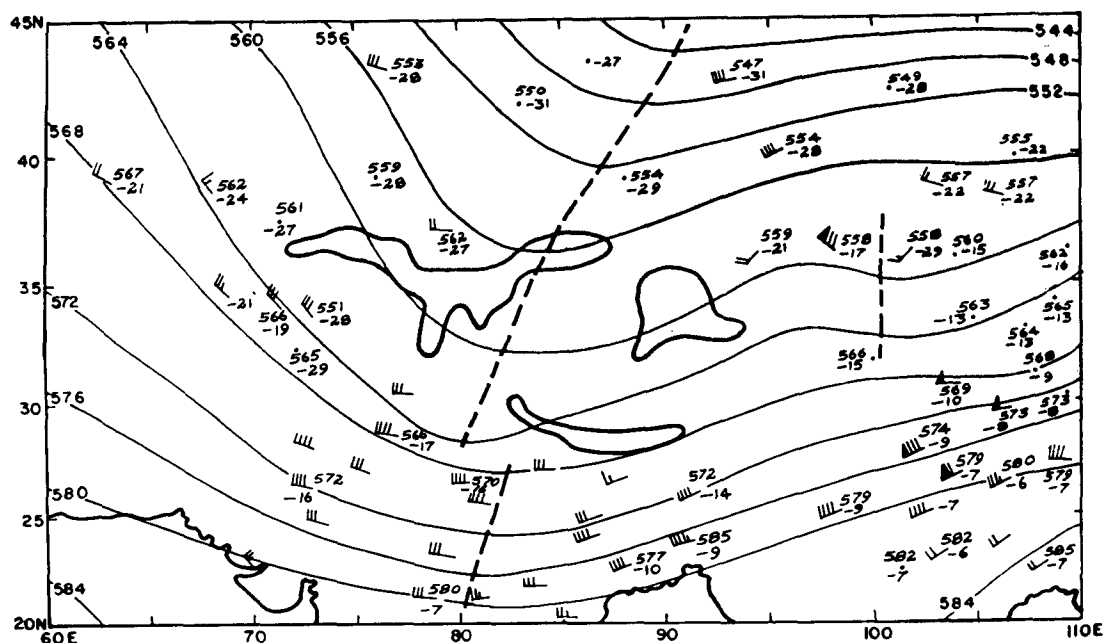


FIG. 3. Standard 500-mb chart of 24 November 1970 at 0000 GMT.

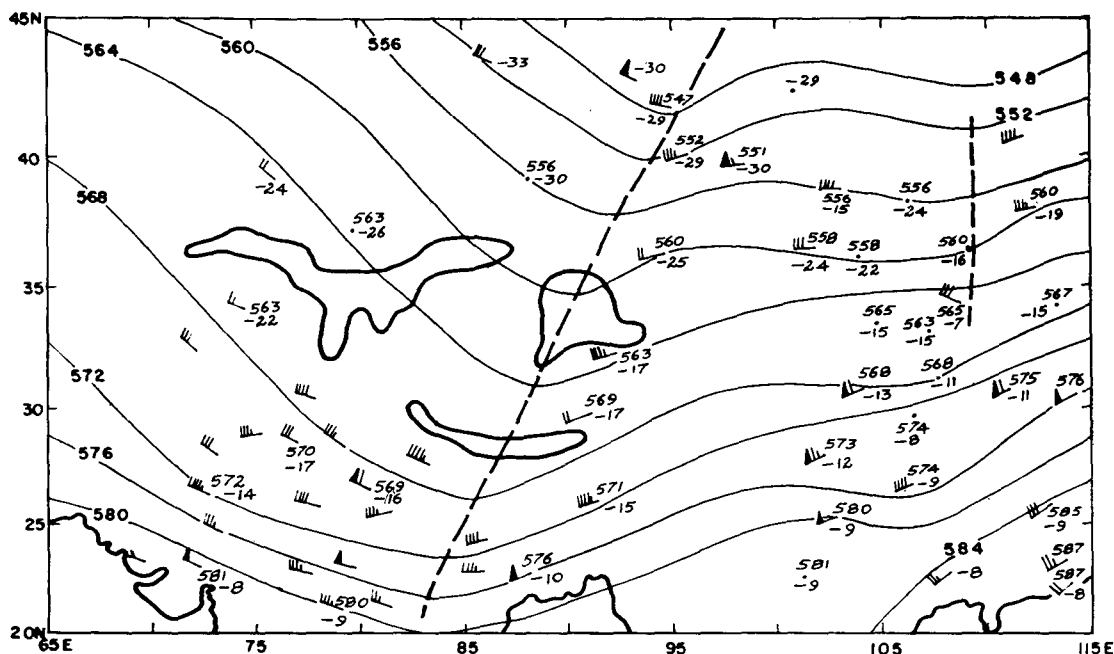


FIG. 4. Standard 500-mb chart of 25 November 1970 at 0000 GMT.

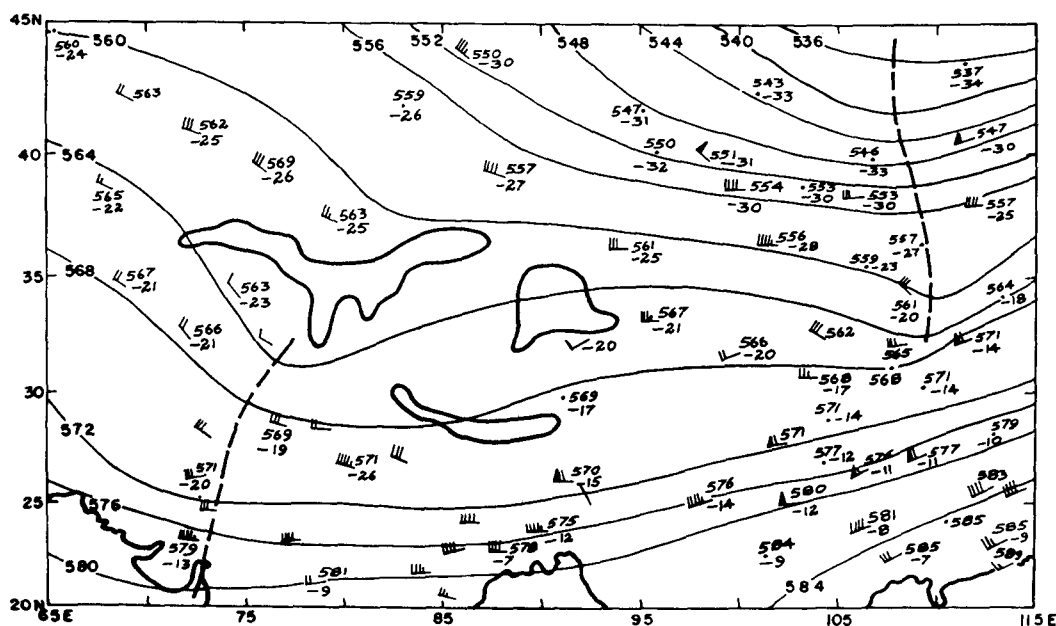


FIG. 5. Standard 500-mb chart of 26 November 1970 at 0000 GMT.

contour analyses at 500 mb over the Tibetan Plateau and its neighborhood. As usual, the mountain barriers (the Kunlun and Everest) have been totally ignored in the analysis. According to these charts, during the period 23–26 November 1970, a deep westerly trough moved across Tibet. On 24 November (Fig. 3) the trough amplified and reached India across Central Tibet. On the next day it moved east and was in alignment with a quasistationary trough over India (Fig. 4). Note that the pressure contours from 5600 to

5680 gpm intersect the mountain barriers, particularly in Figs. 3 and 4. At these altitudes, according to the analysis, there was organized horizontal transport of mass, momentum, vorticity etc., *through* the mountains! We may recall that a number of studies on the weather and circulation over the Indo-Tibetan region have been made on just such types of analyses (Pisharoty and Asnani 1960; Ramaswamy 1962, 1965, 1966, 1968, 1969).

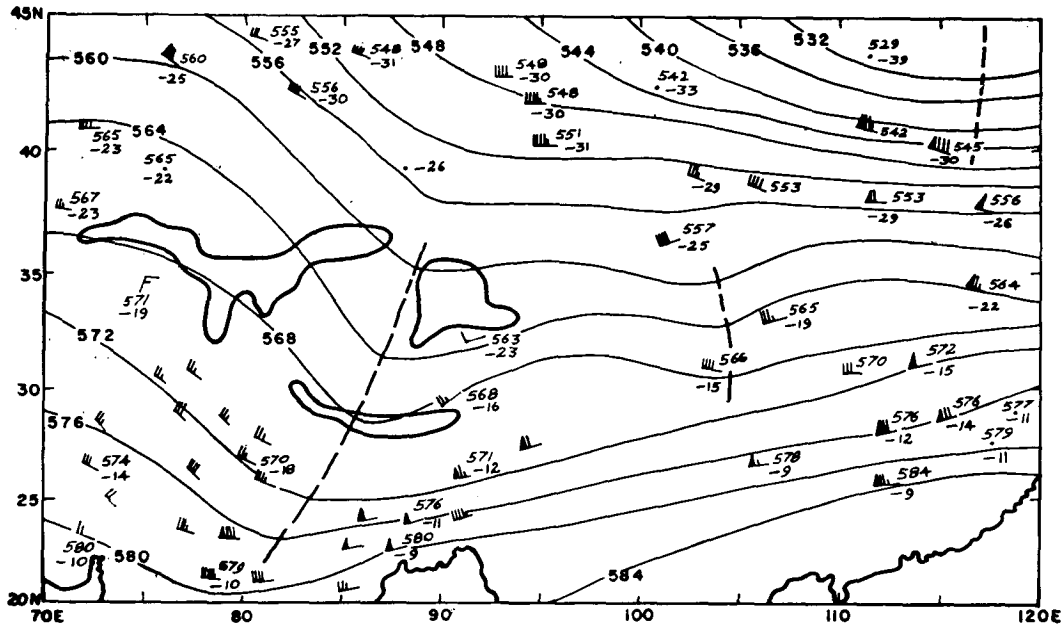


FIG. 6. Standard 500-mb chart of 27 November 1970 at 0000 GMT.

Having seen that the usual analysis is unrealistic, let us examine the circulation pattern from charts which have been re-analyzed on the basis that no large-scale exchange of air is possible through the Kunlun or Everest barriers. The re-analyzed charts are given in Figs. 7-11. In the first case they show that there is no meridional exchange of air across the Tibetan Plateau, so that wave perturbations to the north and south of the Plateau remain as separate systems. That they have, therefore, independent be-

havior is suggested by the fact that when the Indian trough shifted westward from about 83E (Fig. 9) to 73E (Fig. 10), the middle latitude trough moved eastward from about 95 to 107E. When troughs move to the north or south of the Plateau, the circulation changes that take place in Central Tibet are not known at present; therefore our resulting analyses over Central Tibet are highly subjective. Theoretical studies of this aspect may improve analyses in this area. Even at the fringes of the Plateau we are not

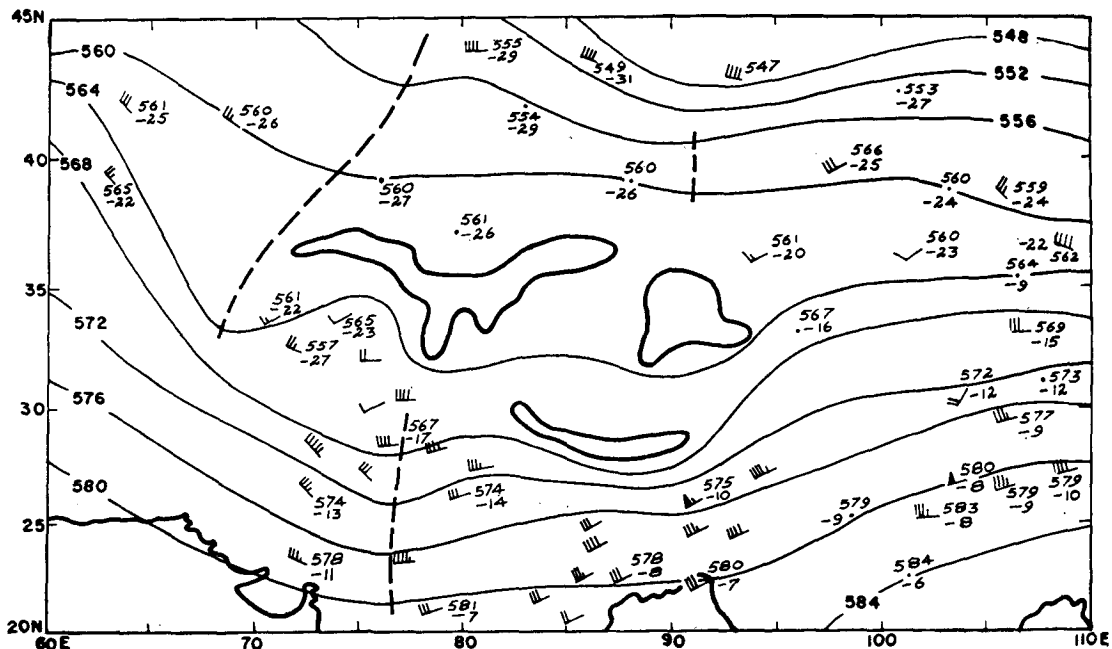


FIG. 7. Revised 500-mb chart of 23 November 1970 at 0000 GMT.

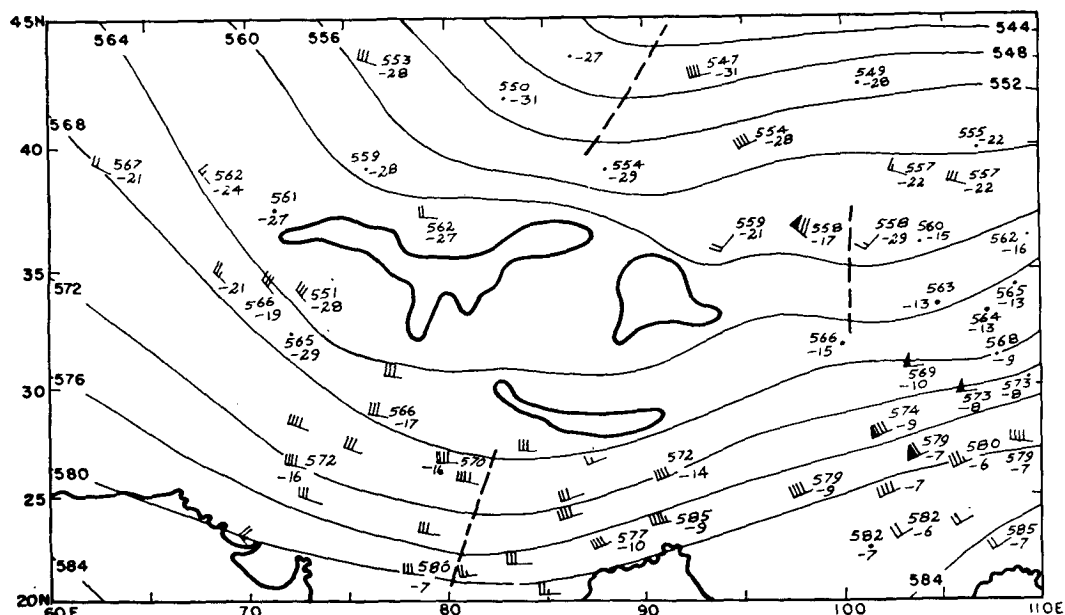


FIG. 8. Revised 500-mb chart of 24 November 1970 at 0000 GMT.

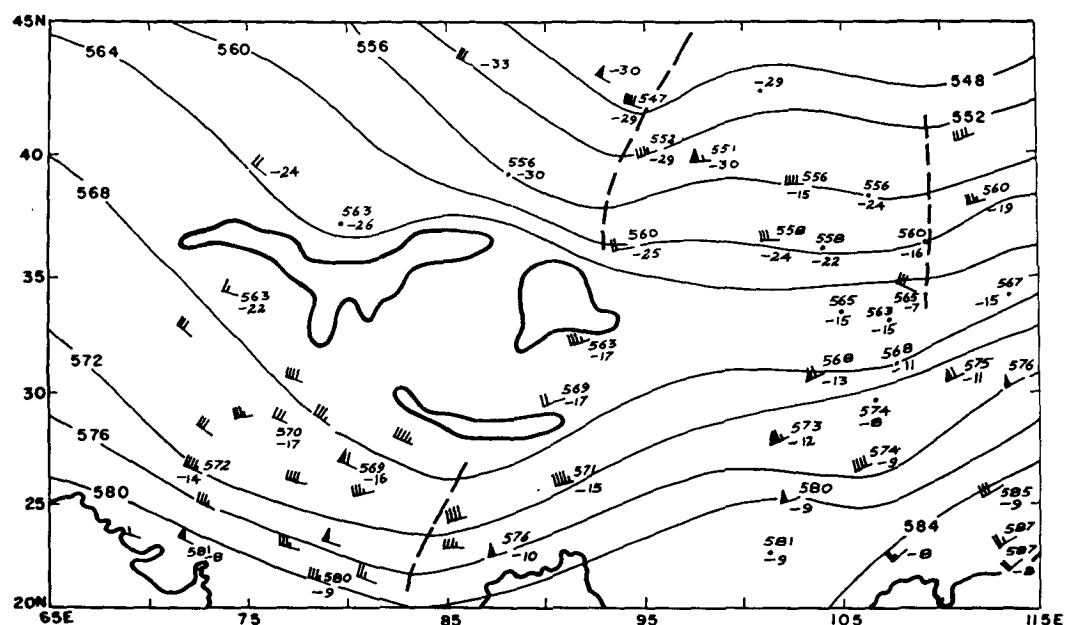


FIG. 9. Revised 500-mb chart of 25 November 1970 at 0000 GMT

able to account for some of the observations. This probably indicates the presence of eddies locally generated by the orography.

To the west and east of the principal Tibetan mountain system, i.e., from about 72 to 94°E, troughs at 500 mb may extend all the way to the tropics. In Fig. 7 the trough along 69°E extends south of 35°N. However, as it moved east, its southern portion dissipated over Tibet in the lee of the Kunlun range (Figs. 8 and 9). To the north of Tibet the trough survived

but its amplitude was remarkably reduced. Perhaps the frictional forces at the Kunlun barrier were partly responsible for this.

According to Staff members of Academia Sinica (1958), the dynamical effect of the Tibetan Plateau as a whole on the planetary westerlies is such that the normal streamflow almost throughout the troposphere at the northern and southern peripheries of the Plateau becomes anticyclonic and cyclonic, respectively. The charts presented here suggest that even under situa-

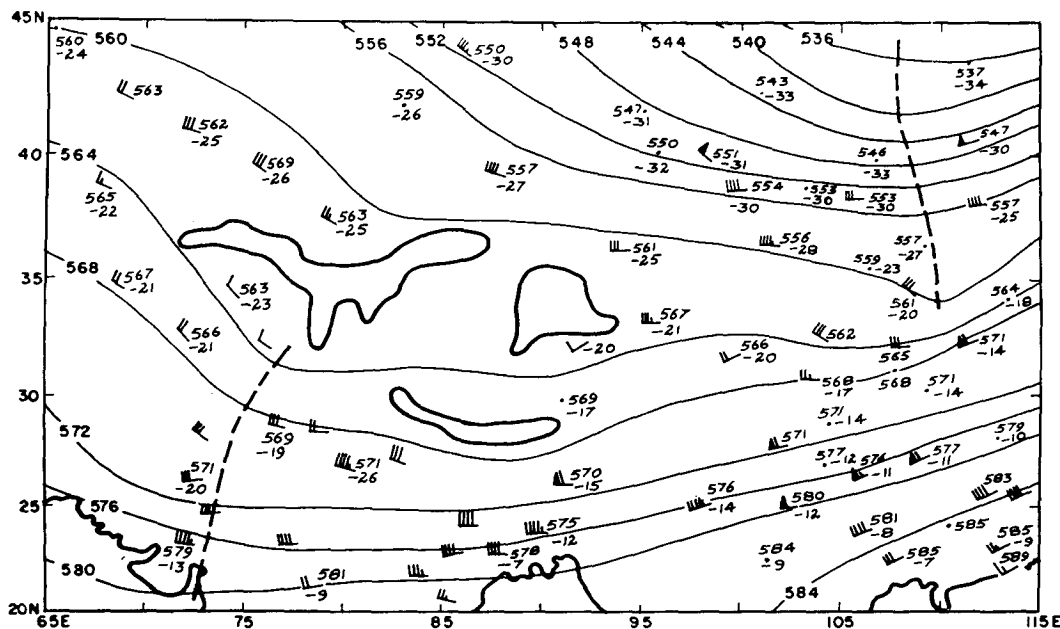


FIG. 10. Revised 500-mb chart of 26 November 1970 at 0000 GMT

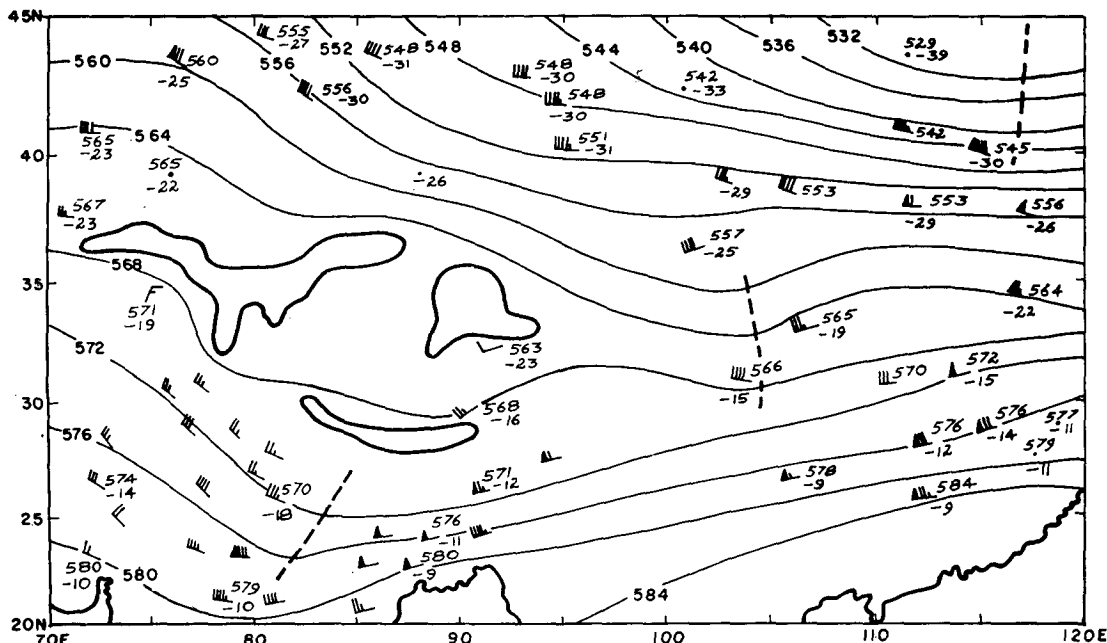


FIG. 11. Revised 500-mb chart of 27 November 1970 at 0000 GMT

tions of pronounced meridional circulation, the Tibetan Plateau exerts an influence at 500 mb which is naturally not found in the usual analysis in which the mountains are ignored.

One may like to note from these charts that the upper air data of the two Tibetan observatories (Bamtso and Lhasa) situated only about 300 km apart are generally not comparable. Though this is not surprising, it reminds us that the existing network of upper air observatories over Tibet permits us, particularly

under low index situations, to make only qualitative analyses at 500 mb, i.e., we can only sketch broad circulation features over the region and not undertake any of the quantitative-type analyses required for numerical weather prediction.

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